

The Loch Ness Monster, Gannets, and Boyle's Law

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There is a relationship between the observed surfacing and diving behavior of fictional creatures such as the Loch Ness monster (affectionately known as Nessie) and nonfictional animals such as gannets. Furthermore, their underwater behavior can be better appreciated with an understanding of Boyle's law, i.e., the volume of enclosed gas samples vary inversely with applied pressure. Students find such a discussion to be a refreshing change from the more traditional gas law examples typically found in general chemistry textbooks.¹

The legend of Nessie dates back to 565 A.D., when St. Columba began his mission to convert Scotland to Christianity (1). While visiting the Loch Ness area one day, he saw what he described to be a giant animal swimming in the water. Since then, thousands of others, many of whom were sober, have claimed to have seen Nessie (2). Such recurring reports have long tantalized scientists and science buffs, and several expeditions have searched for proof of Nessie's existence. In 1973, for example, a Japanese expedition spent \$500,000 searching for Nessie (3), and in 1976 the *New York Times* initiated their own \$75,000 expedition (4). Most recently, a three-day, \$1.6 million expedition was conducted in late 1987 (5). Sonar recordings from some of the expeditions have hinted at the possibility of animate objects 10 m or more in length with diving and surfacing speeds of up to 80 m/min. In 1972, a team led by M.I.T. physics graduate Robert H. Rines produced underwater photos of a flipper appendage which, based on the credentials of the team, convinced many previously skeptical scientists that Nessie was real (6).

Gannets are the largest (1 m) seabird in the northern Atlantic. They are also found in temperate waters around Africa and in the southeastern Pacific, and some winter in Florida. Of particular interest is their ability to dive for food (7, 8). After spotting underwater food from far in the air, they fold back their wings and drop up to 35 m, hitting the water surface at over 160 km/h. As they strike the water's surface, their impact is cushioned by an intricate system of air sacs in their heads, under their skin, and in nearly all of their bones. The gannets dive deeply; their dives last about a minute (a 7-m dive has been recorded); and, with the help of increased buoyancy, as explained in part by Boyle's law, their return to the surface can be quite rapid. As the gannets swim upward, the pressure exerted by the surrounding water on their bodies decreases. This decrease in pressure expands the volume of their air sacs, which in turn increases their buoyancy, which in turn increases their speed, allowing them to chase their underwater prey more effectively.

To see how the gannets' underwater behavior is similar to the Loch Ness monster's underwater behavior, let us first consider what happens to dead Scotch pine trees in the Loch Ness area. It is interesting to note that Nessie has been sighted in only three of Scotland's 500 freshwater lochs—Ness, Tay, and Morar—and that there are similarities among the three lakes that could account for the sightings

(9). All three lakes are very deep (Ness is about 815 ft with pressure exceeding 25 atm at the bottom), and all are surrounded by Scotch pines. Scotch pines yield much more resin than other pines. After dead Scotch pines fall into a loch and sink to the bottom, the high water pressure squeezes resin out of the wood. The resin forms a tight coating around the trees that traps gas from the decomposing wood. The resulting, buoyant, resin blisters float the trees to the surface. As with gannets, the trees pick up speed as they near the water's surface. Unlike gannets' air sacs, the resin blisters burst, and the trees dive back to the bottom of the loch. Occasionally trees will reach the surface where they rear their monsterlike heads before they dive from view.²

Let us now see how it is possible for somebody to mistake a tree for a monster. Interestingly enough, about 80% of all reported sightings of Nessie occur under conditions of surface temperature inversions, which favor and enhance atmospheric image distortions (10). For anyone who has observed the appearance of water rippling at the end of a hot road, it is easy to understand how both eyes and cameras can be fooled. The bending of light rays in the atmosphere leads to many interesting observations. For example, if a temperature inversion layer is moving, images can grow, shrink, or seem to be in motion. They can appear and disappear without a sound or a ripple, as many of the sightings describe. Trees protruding from the water's surface can appear kinked and flattened, and then, minutes later, they can appear to be curved backward and vertically distended.

A recent analysis (11) of the data from the several Loch Ness expeditions has shown that the monsters detected by the cameras or sonars were floating debris such as pine trees, gas bubbles, or schools of fish. Mathematical errors have been discovered. Objects reported to be in motion were found to be stationary; careful scrutiny of the sonar tracings showed that the sonar devices themselves had moved. Even the famous computer-enhanced flipper appendage photographs were found to have been retouched after the computer enhancement (11).

However, hope springs eternal, and this author is one of many who wonders in awe if Nessie may nevertheless be alive and well.

Literature Cited

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¹ The details provided in this paper are meant to serve as background information for instructors. It is not this author's intention to imply that this complete discussion be presented to students.

² The pine tree theory was proposed by Robert Craig, a Scotch electronics engineer, and reported in the British magazine *New Scientist*, circa 1982. This author is unaware of any evidence to support Craig's theory.